AD-A189 501 STRATEGIES FOR SUSTAINING SOLDIER AND UNIT PERFORMANCE 1/1
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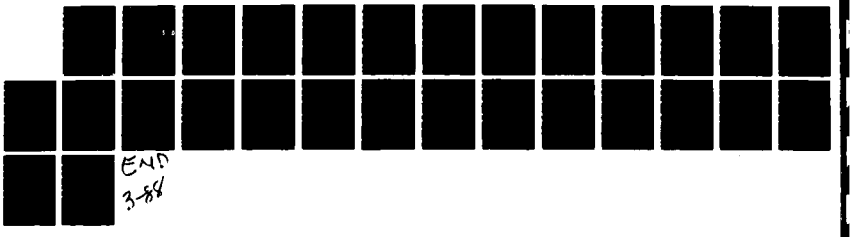

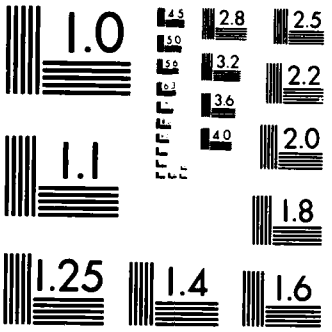

Report WRAIR-NP-87-11

STRATEGIES FOR SUSTAINING SOLDIER AND UNIT PERFORMANCE IN CONTINUOUS OPERATIONS

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PREFACE

This paper is one of a series of occasional, informal accounts of work in the Division of Neuropsychiatry at the Walter Reed army Institute of Research. The reports generally address topics in Army preventive medicine for which implementation responsibility lies significantly outside the Medical Department. Although their contents may overlap partly with our publications in the scientific literature, most papers are based on trip reports, briefings, and consultations involving specific Army audiences. Comments to the senior author are welcome.

This work was supported by Research Area III -- Health Hazards of Military Systems and Combat Operations -- of the U.S. Army Medical Research and Development Command; MG Philip K. Russell, Commanding.

In February 1986, the Army Studies Group at the Department of the U.S. Army evaluated the Army's posture for conducting sustained and continuous operations (CONOPS). These issues were discussed with particular reference to the latest Air Land Battle doctrine described in the U.S. Army Operations Field Manual 100-5. As a result of these deliberations the Vice Chief of Staff directed the commander of the Training and Doctrine Command (TRADOC) to perform a special staff study on CONOPS. TRADOC in turn convened a Study Advisory Group (SAG) on CONOPS and enlisted the assistance of representatives of thirteen organizations for the conduct of the study.

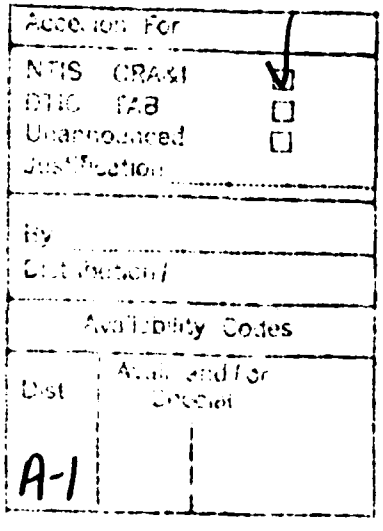
Members of the Walter Reed Army Institute of Research (WRAIR) and the Army Research Institute (ARI) for the Behavioral and Social Sciences agreed to jointly take on two significant efforts for the SAG: 1) to review the scientific and technical literature to determine what previous studies tell about soldier/unit performance in CONOPS; and 2) to present a compilation of general human factors principles that can be applied in planning, preparation and conduct of sustained and continuous military operations, and a description of research planning underway to enhance the Army's CONOPS posture.

The efforts by WRAIR and ARI personnel resulted in submission of two technical reports and formal briefings of results, one for each Phase of the study, to the SAG, the first in October and the second in December 1986. These two reports were subsequently incorporated into the SAG's overall final report:

G.A. Dewulf (ED.) Continuous Operations study CONOPS) Final Report. (TRADOC CACDA Report #ACN 073194; DTIC Report #AD-B111-424L). Fort Leavenworth, KS: U.S. Army Combined Arms Combat Development Activity, April 1987.

The second report, as submitted to the SAG, is reproduced here as guidance for planners, tacticians and commanders who envision engaging

our forces in CONOPS. "Strategies for Sustaining Soldier and Unit Performance in CONOPS" serves as a "state-of-the-art" indicator of what we know, where we are, and where we are headed in the continuing search for explanations of how and why people perform the way they do when asked to maintain effective performance while sleep deprived.



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1 Summary of Phase I

As a part of the overall TRADOC Continuous Operations (CONOPS) Study, members of the Walter Reed Army Institute of Research (WRAIR) and the Army Research Institute (ARI) for the Behavioral and Social Sciences reviewed the scientific and technical literature to determine what previous studies tell us about soldier/unit performance in CONOPS (Belenky et. al., WRAIR/ARI CONOPS Phase I Report, October 1986). This report for Phase II of the CONOPS study presents general human factors principles to be applied in planning, preparation and conduct of Sustained and Continuous Military Operations and some previews of research planning underway to enhance our CONOPS posture. A summary of the Phase I report is presented first.

1.1 Definitions (U.S. Army Field Manual 22-9)

1.1.1 Continuous Operations (CONOPS) are defined as continuous combat with opportunities for sleep, though these opportunities may be brief and scattered through the day and night.

1.1.2 Sustained Operations (SUSOPS) are defined as continuous combat with no opportunity for sleep.

1.1.3 Within any CONOPS there will likely be periods of SUSOPS; and during CONOPS, for some personnel (e.g. those involved in command, control, communication and intelligence (C^3I), sleep will be more severely restricted than for others.

1.2 Review of Research on Performance in CONOPS

Performance degrades as a result of cumulative sleep deprivation and fatigue in CONOPS and SUSOPS. Mental performance degrades more rapidly than physical performance. Initiative, integrating information, planning and plan execution are the aspects of mental performance that degrade most rapidly. With complete sleep deprivation (SUSOPS), alertness and performance decline rapidly, with mental performance declining in speed and accuracy approximately 50%, and latency to fall asleep (when permitted to do so) declining to less than one minute after two days total sleep deprivation. With partial sleep deprivation (CONOPS), alertness and performance decline more gradually, but after 5-7 days of partial sleep deprivation (e.g. sleep limited to 4-5 hours each night) alertness and performance decline to the same low levels as those seen following two days of total sleep deprivation.

1.3 Implications of the Research Literature for Strategies of Sustaining the Soldier in CONOPS/SUSOPS

The U.S. Army is developing and applying a doctrine for managing

sleep and alertness in CONOPS. The current Training and Doctrine Command (TRADOC) Study Advisory Group (SAG) on CONOPS is part of this development. Researchers, tacticians and doctrine developers combine what is already known from laboratory and field studies of CONOPS with findings from ongoing and newly scheduled studies whose goal is to develop new behavioral and pharmacological techniques for managing sleep and alertness in CONOPS. This process in the U.S. Army is proceeding in parallel with similar developmental efforts in other armies, and in the U.S. Navy and Air Force. In the near future this doctrine will:

1.3.1 Identify those positions in which personnel are most likely to suffer sleep deprivation in CONOPS and SUSOPS and adapt adequate manning doctrine, over-learning and cross-training to reduce the impact of continuous battle upon these personnel.

1.3.2 Optimize the timing and duration of naps in CONOPS in order to make the most of sleep opportunities.

1.3.3 Field drugs to facilitate and improve the efficiency of brief sleep in CONOPS.

1.3.4 Field drugs to maintain normal alertness when for 2-3 days, sleep is not possible (as in SUSOPS), and to reduce the need for sleep and maintain normal alertness when for days or weeks only limited sleep is possible (as in CONOPS).

2 Strategies for Sustaining Soldiers in CONOPS - Phase II

2.1 Human Factors Principles for CONOPS

Human factors principles for planning, preparation and conduct of CONOPS/SUSOPS were derived from careful interpretation of the voluminous literature on biological, behavioral and performance aspects of work/rest activities, sleep deprivation, sleep management and extended military operations studies (e.g. those found in Krueger, Cardenales-Ortiz & Loveless, 1985, Englund & Krueger, 1985 and Krueger & Englund, 1985), and from consultation with our counterparts in the U.S. Navy, the U.S. Air Force, the Canadian and British Armed Forces (especially Naitoh et. al. 1986, Woodward & Nelson, 1974, APRE, 1986). To all of them we owe a debt of gratitude, for the principles outlined here are a result of their work.

The principles listed here in executive summary form include considerations for use in staffing military units for CONOPS, for training and preparation before CONOPS, for work/rest scheduling and sleep management during CONOPS. Brief descriptions are presented of ongoing sleep management research programs, efforts to lighten the soldier's load and implementation of concepts of good physical fitness and nutrition as they pertain to CONOPS.

2.1.1 Staffing/Organizational Principles

Armies planning to fight CONOPS must organize and staff their organization/units (e.g. for the U.S. Army - their TOEs: Tables of Organization and Equipment) in preparation for CONOPS. Some units should be taliored specifically for such combat operations.

Units should be staffed with sufficient personnel to provide some redundancy and to allow soldiers to work in shifts in select organizational elements (e.g. communications and command-control personnel).

Units should increase staffing in areas known to have shortfalls for CONOPS (e.g. support platoons, transportation in logistics elements, communication elements, etc.).

Reserve platoons should be judiciously re-created for select applications (e.g. like the old armor security squad).

Where possible, tasks should be modified to minimize effects of sleep loss (e.g. design a vigilance task so the operator must occasionally do something else).

2.1.2 Training and Preparation for CONOPS

Leaders must train themselves to organize and supervise their units for the particular idiosyncrasies of CONOPS.

Generally, the higher the state of training prior to sleep loss, the longer performance deterioration can be staved off (but it is still difficult to go beyond 2-3 days without sleep). Thus, units should be highly trained before SUSOPS.

Individuals should be trained on complex tasks to degree of "overlearning," the point at which responses become almost automatic and therefore resistant to stressful, fatiguing conditions.

Personnel should be cross-trained to take over other crew members' tasks; individual rotation gives some members a rest.

Unit physical conditioning programs should be conducted for strength and physical stamina.

Soldiers ought to be in good physical shape, but, overall physical fitness is not sufficient. Soldiers should train select muscle groups to do frequently repeated physically demanding tasks (e.g. a light infantryman should train with a loaded pack on his back for extended periods of time).

"Train as you plan to fight." Physical fitness for military tasks means that we should train as we plan to fight. Thus, load bearing marches should be

part of an infantry training program.

CONOPS requirements go beyond physical endurance. They generally involve much cognitive work and mental stress. Therefore, units should consider the unique aspects of CONOPS in the conduct of their stress management programs. (U.S. Army Field Manual 26-2).

There are large individual differences in tolerance to sleep loss. Individual soldiers must know how well they tolerate working without sleep. Some may be overwhelmed by loss of one night of sleep; others may take considerable sleep loss in stride.

Units should train under conditions of continuous and sustained operations so all personnel will recognize effects of sleep loss, their own responses to it, as well as those of others.

Leaders should use constructive, purposeful, combat-relevant training to build morale. Morale, motivation, cohesion and leadership generally sustain soldiers in combat and bolster performance, and help considerably in CONOPS.

Commanders should develop and promulgate a work/rest schedule and sleep discipline plan; and then use it.

Consideration should be given to identifying and selecting personnel who prefer and are able to adapt to different shiftwork schedules and then honoring such preferences (e.g. owls work at night and larks during the day).

Commanders should consider the merits of the concept of appointing a Second in Command (2IC) for SUSOPS so that the battle can be conducted without interruption while the commander gets rest.

Commanders should identify those places where reliance is on the performance of a few individuals and try to lessen such dependence. Back-up personnel capability is essential.

2.1.3 Reducing Performance Impairment Risks During CONOPS/SUSOPS

Soldiers should get a 12-hour period of "off duty time" (for rest and sleep and as free of duties as possible) immediately preceding a prolonged work (SUSOPS) episode. Although one cannot store up sleep, this will delay the onset of performance degradation.

Units should use the work/rest and sleep discipline plan. It is the field commanders' and NCOs' responsibility to insure unit members comply with sleep management recommendations - in pre-deployment, deployment and combat phases. Set the example!

Work/rest plans should recognize the influence of known circadian factors. Expect performance lulls from 0300-0600 and 1630-1800 hrs. These lulls will be more easily noticed on continuous, monotonous tasks such as CRT vigilance. Additionally, cognizance over other circadian factors is also important, (e.g. assignment of personnel to rapidly rotating shift changes desynchronizes bodily rhythms and brings about performance degradations faster).

Soldiers should take periodic breaks or rests from tasks; sometimes mild physical exercise or recreation will help. Rotate duties of individuals between visual, mental and physical tasks if possible. This can relieve some effects of fatigue and visual strain, and increase alertness; such relief will be moderate however and is not to be overrated.

When performance begins to degrade in a unit, find time for soldiers to nap, change routines, or rotate jobs if they are cross trained.

Crewmembers cross-trained on relatively routine jobs should rotate tasks to reduce performance deterioration (e.g. tank crew members rotate jobs periodically; seated sentries rotate with those walking the perimeter).

Performance on complex tasks involving decision making benefits from crew rotation only if personnel are well-practiced and expert in shifting functions. Crew rotation on complex tasks is advisable only when members are highly trained to shift functions.

Let the most sleep loss affected soldiers do tasks that can be accomplished at a pace set by the worker, not by the job. Sleep loss has less impact on self-paced jobs.

Allow more time for execution of tasks (i.e. task rate) because as soldiers become tired, performance will be slower - the "friction" of CONOPS!

Communication - Take extra care to make communication (messages and orders) clear and simple. They should be written when possible. After about 36 hours of sleep deprivation (SUSOPS) there is a marked deterioration in ability to register and understand information. Repeating back orders to insure they were understood is a useful technique, but memory lapses that follow significant sleep loss may be detrimental. Encourage everyone to write down work to be done or messages received, and have others check what has been written for clarity and legibility.

After about 24-36 hours without sleep, decisions, calculations, etc. should be cross-checked by a 2nd person for accuracy and completeness. Mix rested with unrested soldiers as CONOPS continues. Since it is unlikely two members of a unit will become sleepy or make the same mistake at exactly the same time, teaming up two or more persons to do a job is a useful concept in SUSOPS.

Special consideration should be given to personnel responsible for tasks more adversely affected by sleep loss (e.g. those undertaking surveillance and/or command/control functions).

Mental stimulation, increased incentive, interest or morale can, within limits, often raise the level of mental alertness, and improve performance.

Mild physical activity (e.g. walking around) can temporarily alleviate fatigue from sleep loss. Exercise, noise and cold can give temporary help; however, they increase the physical cost and lead eventually to greater fatigue.

The lightening-the-soldier's-load concept is a workable, important doctrine for the light infantry. Minimized loads, based on combat planning factors (e.g. METT-T: mission, enemy forces, terrain, troops available and time) allow for movement and maneuverability, and conserve energy for engagement with the enemy.

To improve CONOPS capability, water and meal consumption discipline must be instituted to ensure proper hydration and caloric intake.

Attention to personal logistics (e.g. timing of hot meals, provision of coffee or other caffeine containing drinks) can help maintain morale.

Personal hygiene (e.g. changing socks, uniforms, cleaning up etc.) can help maintain morale as well as health and in a preventive medicine way, help stave off psychological stress and medical casualties.

Stimulant drugs can attenuate decline in mental & physical performance in SUSOPS and CONOPS; but benefits with currently used drugs are limited because, use of currently available drugs to counteract several days of total sleep loss leads to rebound fatigue when they are discontinued; and while restoring alertness and motivation, these currently available drugs can impair judgment.

Research is underway to identify new stimulant drugs that can maintain normal alertness and performance in the face of 2-3 days of complete sleep deprivation (SUSOPS), and in the face of days or weeks of partial sleep deprivation (CONOPS), without impairing judgment while the drug is in use and without rebound fatigue when the drug is discontinued.

2.1.4 Sleep Scheduling

Normally, soldiers should get 6-8 hours continuous sleep time per 24 hour period. Soldiers should be able to sustain performance under these conditions indefinitely.

Performance degradation can be averted by preventing or reducing sleep debt. This requires using a properly established work/rest/sleep schedule. Some of the rest period must be used for sleep. The only really effective

remedy for sleep loss is sleep. Naps are beneficial and should be taken as frequently as possible.

As a minimum, there should be at least 4-5 hrs sleep per 24 hours, preferably in a single unbroken period. Four + hours of sleep in each 24 hr day is likely to maintain adequate performance over a week or more, but by that time, for some soldiers, sufficient sleep debt will have accrued to make them as fatigued as if they had gone for 2 days without sleep. This precaution is particularly pertinent to command and control personnel.

A small amount of sleep relative to that lost is very beneficial. For example, 4 hours of sleep after 90 hours of wakefulness markedly improves performance and mood. For full recovery, 12 hours uninterrupted sleep should be allowed after 48 to 72 hours without sleep.

Soldiers should be encouraged to take naps during CONOPS. Some of the rest period(s)) must be used for sleep because only sleep can prevent sleep debt from increasing.

Generally, the longer a nap, the greater the improvement in performance and the less sleep inertia (groggy slow responses) upon awakening. Naps are generally more restorative if taken between 0300-0600 and 1600-1800 (during the circadian lulls), however there is also greater sleep inertia upon awakening from naps during these times.

Since opportunities for naps in CONOPS come at unpredictable times, an opportunity for a nap should be taken regardless of the time of the day. Soldiers should be told to take naps when they safely can.

A key factor in sleep management is to avoid accumulation of daily sleep deficit. If personnel are able to sleep only 2 or less hours one day, then this should be made up by sleeping for more than 5 hours the next day.

If necessary, sleep can be taken in short periods of 10-30 minutes. This method is less recuperative than long blocks of sleep; so the longest periods feasible should be allotted. Apply the basic rule of sleeping at least 4-5 hours per 24 hour period.

Sleep-inducing drugs may be useful to induce brief, restful sleep during lulls or as part of duty rotation in CONOPS. They may also be useful during long range deployments by air.

Research is underway to identify effective short-acting sleep-inducing drugs that would ensure a brief restful nap during CONOPS, while reducing sleep inertia, and leaving no untoward residual drug effects (e.g. headache or hangover) upon awakening.

Research is also underway to identify short-acting sleep-inducing drugs for use in long range deployments by air.

2.1.5 Recovery Sleep Concepts

After 36-48 hours of continuous work without sleep, six hours of sleep (or less) is generally inadequate to return to normal performance levels. Four or more hours of sleep can raise performance levels from approximately 50% of baseline to about 75% of previous performance levels.

A combination of 12 hours sleep/rest (about 8-10 of which must be sleep) are required after 36-48 hours acute sleep loss, although subjective fatigue may linger until the third full night of sleep.

24 hours sleep/rest are recommended (about 15 of which are sleep) after 36-48 hours sleep loss under conditions of high workload (12-16 hours per day). This is particularly applicable for those who have high cognitive workloads.

Sleep loss of 72 to 96 hours will require more than one solid night of recovery sleep before performance recovery is complete. Although there are wide individual differences, after 72 hours or more acute sleep loss, 2 to 3 days time off from normal job duties (during which the individual may sleep or rest or carry out light duties at his own pace) are usually required to restore performance to 100% of "normal performance" levels. Where mission requirements dictate, less time off for rest and sleep, 8-16 hrs, may restore individuals to levels of performance between 50-80% of normal performance. This may be acceptable given the tactical situation.

Three to 5 days are required to initiate biological adaptation and return to normal day/night cycle from short stints of working the night shift. Three to four weeks are required for full adaptation of biological rhythms to extended periods of atypical work-rest schedules (as in night shift work).

After enduring a stressful period of sleep loss and having gone to sleep,soldiers should not be awakened for duty until they have obtained adequate sleep, unless one is prepared to accept very low performance efficiency in their work. Restlessness of some individuals may disrupt attempts of others to get sleep. Soldiers will have to become very cognizant of their fellow team members' sleep needs and avoid unnecessary awakenings of others. A glaring lack of such courtesy is apparent in most field exercises. - We are our own worst enemy here.

The performance of individuals just after being awakened from a normal night of sleep typically will be below normal (groggy and slow) for at least 15 minutes until they "wake up". This is called sleep inertia.

Sleep and rest are not synonymous. Sleep fulfills a biological need that cannot be denied indefinitely. Rest is what a person does when he or she claims to be "relaxing" - a change in a pattern of work activity. For the soldier, rest usually means time away from specific military tasks and may include reading mail, eating a meal etc. but, it may also mean doing other light duties away from his regular set of tasks, preferably ones that he can

do at his own pace.

When a second combat phase/period is expected to follow shortly, sleep management after the first combat is important. This first post-combat sleep period should be allowed to extend either to spontaneous awakening, or for 10 hours (whichever comes first).

The most important point is that one should pre-plan when soldiers are to expect some rest and sleep.

2.1.6 Work/Rest Scheduling

A work/rest schedule takes into consideration the nature of the work to be done, its interaction with others doing their work, rest and sleep time, how far away from the work station is the rest or sleeping location, meal provisions, showering facilities, mail call etc., and when and where in the 24 hr day these things occur.

Choose the schedule that gives the greatest amount of contingency time - time that can be used to make up for the inevitable delays that occur because of snafus, errors, and other uncontrollable variables.

Several different work/rest schedules might work for particular situations (e.g. 12 hrs on/12 hrs off duty; rotating 8 hr shifts among 3 teams; 6 hr on/off shifts; work 10 hrs on/off 14 hrs). There are obvious and not-so-obvious advantages and disadvantages to each.

Imposing phase shift rotations (rolling schedules e.g. 8 hr on, 8 hr off, 8 hr on, 8 hr off) on successive days desynchronizes biological rhythms and is not recommended. It is preferable to begin work shifts about the same time each day. If a rotating schedule is necessary, work periods should occur later during each successive day. That is, a soldier would start work later as opposed to earlier each day.

12 hrs on/12 off (12 hrs work per 24 hrs) is attractive for many combat arms applications because individual work shifts are predictable and such a schedule provides enough time for a normal sleep period of 7-9 hrs and time to do "personal business". It is easy to set up and to maintain. Under conditions of light to moderate physical and/or mental workloads this schedule works quite well.

No matter what the shift arrangement, expect personnel scheduled to work through 0300-0600 hrs, particularly those doing vigilance tasks, to experience performance deficits.

Many military activities seem to lend themselves to 10-12 or even 14 hour work shifts - putting an operation into effect and then completing it.

The potential benefits of staggering and overlapping shifts (e.g. some members of a Tactical Operations Center (TOC) reporting to work on

staggered 12-hr shifts) should also be considered. The entire shift does not rotate at the same time, providing some overlap for task transition continuity.

A tabular synopsis of some of the effects of sleep deprivation is presented in Table 1 (APRE, 1986).

2.2 Sleep and Alertness in CONOPS

2.2.1 Current Directions in Doctrine Development

The development and application of a doctrine for managing sleep and alertness in CONOPS entails work with respect to nap timing and duration, cross-training, rotation, and manning; the use of short-acting sleep-inducing drugs during long range deployments and CONOPS; the use of drugs to maintain alertness acutely during complete sleep deprivation (SUSOPS) and chronically during partial sleep deprivation (CONOPS); and developing a better understanding of the neurobiology of initiative, motivation, alertness, sleep and fatigue.

2.2.2 Naps and Sleep Discipline in CONOPS

Sleep discipline is undergoing re-evaluation in the U.S. Army and in other armies (e.g. British, Canadian, West German, French, and Israeli). Making an analogy to water discipline, in the past, water discipline meant doing with as little water as possible. More recently it has been realized that such an approach leads to dehydration and a decrease in combat effectiveness. Water discipline now means enforcing adequate fluid intake to maintain good hydration. Sleep discipline is undergoing a similar revolution. In the past, sleep discipline meant doing with as little sleep as possible. This ignored data from a variety of field and laboratory studies that performance degrades to unacceptable levels in 48-72 hours without sleep. A new sleep discipline is emerging which entails enforcing adequate sleep management to maintain good cognitive performance. This new sleep discipline will set guidelines, standards and procedures to insure soldiers get sufficient amounts of sleep during CONOPS.

Individual soldiers, particularly those with command and control responsibilities, need 4 or more hours sleep in each 24 hours to sustain combat effectiveness for more than a few days. To maintain combat effectiveness in CONOPS, soldiers must have periodic naps. The longer the nap (i.e. the closer the nap is in length to normal requirements of 6-8 hours sleep in each 24 hours) the greater the likelihood performance will be maintained and the less sleep inertia upon awakening. Naps are more restorative if taken in the temporal vicinity of the normal circadian lows in alertness occurring even in well-rested persons between 0300-0600 and 1600-1800 hrs. However, there is also greater sleep inertia initially upon awakening when naps are taken at this time. In any case, since opportunities for naps in CONOPS will come at unpredictable times, an opportunity for a nap should be taken regardless of the time of day. The

Table 1: APRE Summary

EFFECTS OF SLEEP DEPRIVATION

Effects on Mental Processes

Lack of concentration
Lapses of attention
Reduced vigilance
Slowing of action
Impaired short-term memory
Loss of insight
Misinterpretation
Visual illusions
Disorientation

Tasks More Adversely Affected

Sustained
Unstimulating
Work paced
Surveillance
Inadequately learned
High workload
Complex decision making

Mood Effects

Fatigue
Depression
Irritability
Loss of interest in surroundings and events
Increasingly dominating desire to sleep

Countermeasures

Rest periods
Short naps
Shorter work periods
Rotation of duties
High state of training
Realistic training
Mental stimulation
Cross-checking
Clear and simple orders
Written instructions

UK's Army Personnel Research Establishment, 1986; Army Code 71378

cognitive performance of older soldiers is more impaired by sleep deprivation and older soldiers generally require longer or more frequent naps for the same restoration of function.

Similar principles can be applied to tank or armored personnel carrier and infantry fighting vehicle crews and to other small group organizations such as battalion tactical operation centers. In CONOPS, a crew may not have the opportunity to withdraw from action as a unit, but can increase endurance by using the procedures of crew rotation when the tactical situation allows. For example, a day can be divided into 4- or 6-hour shifts in which heavy workload or critical tasks are distributed over individuals. During any given shift, some soldiers have the opportunity for rest or performing light miscellaneous details whereas others are engaged in heavier work or cognitively demanding tasks. Certain principles can be invoked in scheduling duty positions or individuals at a given time. Graber, Rollier and Salter (1986) suggested a infantry fighting vehicle (mechanized armor forces) team schedule that has the company commander resting during the first night shift (say 2000-0200) and awake during the 0200-0800 period on the assumption that the complexity of the cognitive demands will be greater than during the earlier shift. Additionally, platoon leaders and platoon sergeants would not be on the same work/rest schedules. A reasonable schedule for an artillery howitzer crew would partial out responsibility for ammunition carrying duties over several work shifts (or, task load could be shared within shifts).

Field studies are being conducted to develop and refine sleep discipline doctrine. Non-invasive, non-intrusive, solid state, wear-and-forget sleep/activity monitors are being used in studies of sleep and activity in field training exercises and force development tests to identify those personnel positions in combat units most likely to be deprived of sleep. The studies will lead to recommendations regarding cross-training, manning, sleep discipline and other doctrinal SOPs, as well as to objective tests of the effectiveness of these recommendations.

2.2.3 Sleep-inducing Drugs for Use in Long Range Deployments and CONOPS

An area for specific consideration in the development of sleep discipline doctrine is the use of short-acting sleep inducing drugs for use in long range aerial deployment and in CONOPS. Flight times during long range deployments by air are generally long enough to permit an extended nap. Soldiers are often too anxious, too preoccupied with the upcoming mission, or paradoxically, too tired to sleep. Thus, a short-acting sleep-inducing drug that would ensure a restful nap, with no untoward effects (e.g. decrements in performance or increased sleep inertia) upon awakening, would be very useful.

Laboratory experiments underway are designed to study short-acting sleep inducing drugs that might ensure restful sleep during long range

deployments and during lulls in CONOPS. In long range deployments by air, a simple short-acting sleep-inducing drug may be adequate as the duration of the flight is generally longer than the duration of action of the drug and it is unlikely soldiers will need to be fully alert during the trip.

In CONOPS, either an ultra short-acting sleep-inducing drug or an inducing/reawakening drug combination is needed, because soldiers who have taken the drug may have to return rapidly to full alertness if the battle situation changes. In addition, there may be sleep-inducing drugs that not only promote brief efficient sleep, but minimize sleep inertia upon awakening.

Initial studies of sleep-inducing drugs for use in long range deployments were completed in 1986, and a recommendation for fielding a first generation drug for this purpose will be made in 1987. Further studies to refine the recommendation for long range deployments and to investigate the use of sleep-inducing drugs in CONOPS are underway.

2.2.4 Alertness Sustaining Drugs for Use in CONOPS

In SUSOPS there will be no possibility for sleep. In CONOPS, sleep may be brief and fragmented, amounting to "restricted sleep" (e.g. 4-5 hours in each 24 hours). SUSOPS may last for several days. CONOPS may last for days, weeks, or months. Thus, in SUSOPS there is need for a drug that will maintain normal alertness (and hence performance) in the face of 2-3 days of complete sleep deprivation. In CONOPS there is a need for a drug that will reduce the need for sleep so that normal alertness can be maintained for days, weeks and even months in the face of restricted sleep (e.g. 4-5 hours in each 24 hours).

Laboratory studies of drugs for possible use in maintaining normal alertness acutely during SUSOPS and chronically in CONOPS are currently underway.

2.2.5 Tech Base Studies on the Neurobiology of Alertness, Sleep and Fatigue

Despite enormous progress in neurobiology over the last century, we still do not understand the biological (i.e. neurophysiological and neurochemical) basis of the decline in performance produced by fatigue, or how performance is restored by sleep; nor do we know the mechanisms that initiate or maintain sleep. Studies of human psychology indicate the first functions affected by sleep deprivation are initiative and motivation. However, initiative and motivation are not well understood at the level of neurobiology (i.e. at the level of brain events). Studies are underway to delineate the neurobiology of initiative, motivation, alertness, sleep and fatigue. Through these studies, we hope to develop knowledge regarding the neurobiological changes that occur with fatigue and in this way develop new means of reversing or attenuating these changes.

2.3 Lightening the Soldier's Load

The foot soldier in an extended engagement may likely find the weight of the equipment he must carry is an important determinant to his endurance. His energy is better spent maneuvering and fighting, not in carrying unrealistic loads. A U.S. Army Battlefield Development Plan, 1985, states: "Close combat light forces lack the ability to carry all of the equipment needed to fight and survive on the battlefield. New systems are added to the soldier's load without consideration of how they will be carried."

The U.S. Army Infantry Board's suggested load carrying standards for a fighting load is 48 pounds, and for an approach marching-load, 72 pounds. Soldier loads typically exceed these recommended figures. The estimated average individual loads in a Light Infantry Division (LID) company operating under a low intensity conflict, in a temperate climate scenario were 69 pounds for combat load and 104 pounds for marching-load (DRC, 1986; figures based on a soldier load model of the Army Development and Employment Agency, 1986). When a LID company was asked to prepare for a low-intensity, 48-hour operation in which each soldier would carry 2 gallons of water, 4 grenades, and 6 meals the average load was even higher, at 145 pounds (DRC, 1986). Determining performance costs of carrying heavy loads is important because the constant presence of the load may add to one's fatigue, physical discomfort and declining morale, even to the extent soldiers may be exhausted by the time contact is made with the enemy.

To enable troops to sustain maximum fighting effectiveness over the course of a lengthy engagement, a concept called Lightening the Soldier's Load has been advocated by the U.S. Army Development and Employment Agency (ADEA, 1986). The focus of this effort is on determining what clothing, weapons, ammunition, food, water and other items are needed to move and fight effectively as a function of METT-T, and how they should be transported. Thus research in this area involves much more than traditional issues of portability (that is, consideration of weight/bulk ratios, arrangement of load, development of lighter equipment, ease of movement, and comfort).

An additional important concept is that of mission-specific requirements by units: a determination is made as to what equipment actually needs to be carried by the soldier and which needs only to be in close proximity. The distinction between what to bring and what to have nearby represents a fine line, in that light infantry are expected to have a 48-72 hour operational capability before re-supply. Extra weight not only hampers mobility and maneuverability, but wears one out in the process. Yet one does not want to be without necessary equipment.

TABLE 2: Overview of Soldier Load Echelonment Concept

Echelon	Method of Transport	Principal Items	Transport Responsibility
Combat, Light Fighting	Load bearing vest, clothing	Primary weapons and equipment, MRE, water, ammunition	Soldier
Combat, Assault	Assault pack	Ammunition, water	Soldier-Company
Combat, Approach March	Rucksack	Ammunition, MRE sleeping bag, batteries	Soldier Company
Sustainment	A bag	Threat specific equipment (e.g., chemical, anti-armor	Battalion
Contingency	B bag, C box	Extra clothing cold weather parka)	Division-Corps

Source: Dynamics Research Corp, 1986

The heart of ADEA's proposal is the echelonment concept advocating a mission-oriented approach to soldier load. Load type is dependent on mission. The three main echelons, types of general equipment, and transport responsibility are outlined in Table 2. According to this doctrinal strategy, soldiers would carry all or part of a combat load depending on the specific phase of an operation. The load-bearing equipment is to be designed such that "pack shedding" the rucksack is possible while leaving the assault pack intact. Sustainment loads would be transported by small 4-wheel drive all-terrain vehicles; contingency loads by high-mobility, cross-country trailers. Thus, the idea is to cache or "stockpile" on the battlefield what at a given time are mission non-essential items. These items would then be re-supplied to the troops via load-carrying vehicles.

Tailoring the load based on METT-T is designed to direct transport energy for movement and maneuverability to conserve the soldiers' strength and energy for contact with the enemy. Thus, important variables to consider for given load types include distance to be traveled, rate of movement, time allowed for travel, march/rest schedules, type of terrain, anticipated length and physical demands of mission, and environmental characteristics.

2.4 Nutrition

In 1982 the US Army Medical Research and Development Command sponsored a Committee on Military Nutrition Research (under the auspices of the National Research Council) established to provide guidance on issues and research relevant to "nutritional factors that may critically influence the physical and mental performance of military personnel under all environmental extremes" (NRC, 1983). Proceedings on efforts of the Committee (NRC, 1986) summarize the Army's continuing interest and active involvement in research that pertains to the interrelationships of nutritional status, physical activity, work capacity, and work productivity. Army agencies involved include the USA Research Institute of Environmental Medicine and the Natick Research and Development Center.

Inadequate nutrition in combat can manifest itself not only in degradation of performance but also in reduced resistance to disease and ultimately prolonged recuperation from wounds and illnesses. In relation to sustained operations, reduced caloric input can have a negative effect on muscle glycogen levels, especially when coupled with continuous or at least frequent physical activity. Muscle glycogen levels are closely related to exertion and ultimately to the onset of exhaustion in certain types of physical activity. If the soldier is too busy, too stressed or too tired to eat adequate amounts of rations during CONOPS, his carbohydrate intake will be reduced. Sub-optimal carbohydrate intakes during CONOPS preclude the normal cycle of work (muscle glycogen depletion) and eat/rest (muscle glycogen repletion). This reduced caloric input may lead to both physical and mental fatigue and degraded performance (Askew, 1986).

Personnel subsisting solely on the U.S. Army's light weight, dehydrated meal-ready-to-eat (MREs) have been known to lose weight over just a few weeks in field tests (Schnakenberg, 1985). Additionally, there is some indication from aviation accident reports that Army pilots in accidents deemed to involve aviator fatigue had irregular eating schedules or missed one or more meals prior to the accidents (Krueger & Jones, 1978). In various field tests approximating continuous operations, meals are frequently delivered very late or missed altogether, prompting soldiers to allege their leaders show little concern for the welfare of the troops (e.g. Morgan et al., 1985). The relationships between eating regularly, diet, nutrition and performance are not at all clear, but it appears reasonable that eating regularly is quite important in CONOPS/SUSOPS; and providing hot meals at assigned times or when the workload has been sustained can be a real morale booster.

Another consideration is the effect of inadequate fluid intake. The excitement, stress and general rapid pace of events associated with preparing to go to the field can cause the soldier to "forget" to drink and thus enter the early part of a field scenario sub-optimally hydrated. Dehydration may result, especially if the early scenario calls for assault of

a position, rapid air/land deployment to an objective or other demanding SUSOPS scenarios. The relative lack of moisture in the MREs and other packets contributes to the developing dehydration. Soldiers experiencing dehydration tend to "lose their appetite" and reduce food intake. Reduced food intake and dehydration present a "double edged sword" diminishing performance capabilities (Askew, 1986).

Leadership must emphasize scheduled drinking regimens to insure soldiers are properly hydrated going into battle. Given the availability of food and water, once into sustained operations, leadership and self discipline will play key roles in maintaining nutritional levels commensurate with the physical activity and stress of battle. The motivational benefit alone of providing food (particularly provision of a hot meal) to tired, hungry soldiers may be an important factor in a successful SUSOPS.

As pertains to the light infantry, current and developmental food packets take into consideration the weight/volume needs of the foot soldier. Whereas MREs provide 1,200 kilocalories per meal or 3,600 kilocalories per day, the weight (1 pound per meal) and volume make portability of multimeals a concern. The Food Pack Assault, planned as a replacement for the Long Range Patrol ration, has a better weight/volume ratio and provides 1,550 kilocalories per day. This ration has been tested and approved for use over 10 continuous days. The developmental Ration Light Weight provides 2,000 kilocalories per day and is supposed to sustain a soldier for 30 days with no more than 10 per cent loss of body weight. Anticipated fielding is during 1988. Although the latter food packets provide less caloric input than MREs, the improved carrying capability represents an important tradeoff.

2.5 Physical Fitness for Military Tasks

Meeting fitness standards as defined by U.S. Army Physical Readiness Test criteria does not necessarily indicate soldiers are fit to perform mission specific military tasks for prolonged periods of time. A conference sponsored by the Army Physical Fitness Research Institute listed as its main concern the physical requirements of conducting SUSOPS. A study coordinated by the Institute (Drews, 1984) put soldiers through a 5-day simulated light infantry scenario (4 hours sleep per night). The offensive and defensive operations necessitated nearly continuous movement on foot. The average carrying load was 42 pounds. As rated by on-site evaluators, soldiers showed some difficulty in carrying their packs over the 5-day exercise, which included a 10 kilometer road march. The study group recommendation invokes the principle "train as one plans to fight;" that is, to include progressive load bearing marches as part of the light infantry training program. By increasing the distance and load, the aerobic and specific muscle (legs & back) buildup should result in endurance and strength levels which allow load bearing for distance.

2.6 Cross-Training

Tasks may be characterized by their importance, difficulty, time to complete, frequency of occurrence, and susceptibility to degradation (Kopstein, Siegel & Wilson, 1979). Cross-training is important not only for redundancy on critical tasks if a given soldier is disabled, but also to allow for crew rest rotations. Redundancy can additionally serve to ensure accuracy of performance well into a SUSOPS on, say, critical but vulnerable cognitive-type tasks (e.g., calculating map grid locations) by having two individuals perform the same task or having one check the other (via shift overlap, one of the two presumably would be rested). Cross checking on decisions, calculations, etc. for accuracy and completeness is especially necessary after about 24-36 hours without sleep.

2.7 Over-Learning

Over-learning is the process of continuing to train and practice beyond the point where incremental gains in speed and accuracy become negligible. The point of such over-learning is to make responses so automatic they will easily be performed even under very stressful conditions. This form of training has been of traditional importance to the military. The classification of tasks as to their susceptibility to fatigue effects indicates automatic response sequences such as those developed in well-learned tasks are resistant to fatigue and the performance degradations that do occur take the form of errors rather than increased response latency (Wilkinson, 1964). There is substantial evidence from research on fatigue, sleep deprivation and performance that over-learning provides resistance to performance degradations due to sleep deficit (Morgan, Coates, Brown & Alluisi, 1973).

In summary, "extended training beyond initial mastery (over-training) assures extremely high reliability, automaticity, and rapidity of performance. It is a very powerful management tool for counteracting the debilitating effects of fatigue, disrupted diurnal rhythms, stress, etc. on performance" (Kopstein et al., 1979).

3 Summary and Conclusions

A number of initiatives can be taken immediately to improve resiliency of soldiers and their units in CONOPS. Immediate initiatives include 1) staffing units specifically for CONOPS missions, 2) designing and implementing unit sleep discipline plans, ensuring at least 4 hours sleep each night for command and control personnel during CONOPS, 3) lightening the soldiers mental and physical load, especially during combat, 4) providing adequate nutrition tailored to the demands of SUSOPS and CONOPS, 5) insuring high levels of relevant physical fitness, 6) cross-training crewmembers to do the jobs of others, and 7) over-training, particularly on cognitively demanding or monotonous tasks.

Other initiatives (both behavioral and psychopharmacological) currently under investigation that could be available for implementation

within the next 2-3 years include 1) more refined analyses of which personnel suffer the greatest sleep deprivation in command and control groups (e.g. battalion TOCs) allowing more accurate tailoring of sleep discipline to combat operations; 2) recommendations for short-acting, sleep-inducing drugs to promote brief, restful sleep in long-range deployments and CONOPS; and 3) recommendations of drugs to sustain normal alertness in the face of no sleep in SUSOPS and to maintain normal alertness in the face of restricted sleep in CONOPS. Further, research into the neurobiology of initiative, motivation, alertness, fatigue and sleep is underway and will during the next decade, no doubt provide novel means (both behavioral and pharmacological) to sustain soldier alertness and unit performance during SUSOPS and CONOPS.

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

AD-A189 501

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT UNLIMITED
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) WRAIR-NP-87-11	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION WALTER REED ARMY INSTITUTE OF RESEARCH 6b. OFFICE SYMBOL (If applicable) SGRD-UWI	7a. NAME OF MONITORING ORGANIZATION US ARMY MEDICAL RESEARCH & DEVELOPMENT COMMAND
6c. ADDRESS (City, State, and ZIP Code) WASHINGTON, D.C. 20307-5100	7b. ADDRESS (City, State, and ZIP Code) FT. DETRICK FREDERICK, MD 21701-5012
8a. NAME OF FUNDING / SPONSORING ORGANIZATION USAMRDC 8b. OFFICE SYMBOL (If applicable) SGRD-ZA	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) FT. DETRICK FREDERICK, MD 21701-5012	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 3E16277A; PROJECT NO. 879; TASK NO. AB; WORK UNIT ACCESSION NO. 041

11. TITLE (Include Security Classification)
STRATEGIES FOR SUSTAINING SOLDIER AND UNIT PERFORMANCE IN CONTINUOUS OPERATIONS (U)

12. PERSONAL AUTHOR(S)
KRUEGER, G.P, HEADLEY, D.B, BELENKY, G.L, BALKIN, T.J, SOLICK, R.E.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
	FROM 1940 TO 1986	OCTOBER 1987	26

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
continuous operations, continuous performance, fatigue, sleep loss, sustained operations, sustained performance, military performance, soldier performance, sleep deprivation

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This chapter, submitted in a special study of Army conduct of continuous operations (CONOPS), contains a detailed list of human factors principles and recommendations for sustaining performance of soldiers in CONOPS and includes coverage of topics like: training and preparation for CONOPS; sleep scheduling, recovery sleep concepts, work/rest scheduling, naps and sleep discipline, sleep-inducing drugs for use in long range deployments, alertness sustaining drugs for use in CONOPS, lightening the soldier's load, nutrition, and physical fitness for military tasks.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21. ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c. OFFICE SYMBOL
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DD Form 1473, JUN 86 *Previous editions are obsolete.*

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